THE FREEDOMS AND THE CONTROL OF SCIENCE: NOTES FROM THE IVORY TOWER

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THE FREEDOMS AND THE CONTROL OF SCIENCE: NOTES FROM THE IVORY TOWER

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"Legal control" evokes as many fearful reflexes from some scientists as "technology" does from some laymen. Neither group enjoys thinking that its behavior is under surveillance. But everyone knows in his heart that the safety of his children depends on the repression of deviance; for without such a system to restrain the other fellow, social regulation would soon collapse into a pre-civilized plane of blood revenge. Many scientists, already battered by much neo-romantic criticism, will equate any movement toward the control of science with the Vatican's inquisition of Galileo.[1] But it would be as wrong as it is futile for scientists to resist contemporary inquiry about the social merits of scientific and technological progress or to ignore concrete proposals for assimilating these activities to human needs. However poorly the discussion of such themes lends itself to rigorous scientific analysis or laboratory quantification, to have responsible detachment, precise definitions, and orderly argument would be a refreshing successor to some of the noisy rhetoric that has characterized both sides of recent debates.

The age-old impulse to control "dangerous knowledge" is embodied in our primeval myths, like the trial of Prometheus. His theft of fire was but one particular in the charges against him; he was proud of having created the whole range of arts that we would now label the neolithic revolution. His defense, as articulated by the classic poets, was his belief or delusion that the gods had intended to exterminate man in favor of another species. Perhaps Hesiod[2] already understood

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1. The fear may not be entirely unjustified. Although a move was mounted to rehabilitate Galileo some 335 years later by the Vatican, it did not come before the authoritarian repression of scientific inquiry became a part of the Marxian dialectic. *See, e.g.*, Günter, *Brecht's Galileo*, in BRECHT (P. Demetz ed. 1962).

2. Hesiod, the father of Greek didactic poetry, authored the *Theogony*, which systematized the floating legends of the gods, godesses, and their offspring.

the antinomy of cultural and biological evolution.[3] Like Zeus, the Arabs who sacked and burned the great library at Alexandria shortly after the death of Christ were moved by their desire to control or eliminate knowledge which they considered destructive. Critics of technology today are heirs of this perhaps partially justifiable tradition—justifiable because many would charge that rampant technology, the object of concern, can be identified with social ills and change in every sphere. Wherever we may fail to meet our aspirations for good and peaceful lives, technological enterprises will surely loom large. The arms race and the threat of global annihilation, the displacement of men from creative work, the banalities of mass culture, widening economic inequalities in the face of continued "progress," greedy and reckless depredations of the environment, are all in the debit account.[4] Besides these explicit dys-humanities, we all believe that technology could be directed more beneficially than it has been toward its promise of improving the human condition. Critics of technological misdirection will continue to seek points of attack over the whole gamut of scientific and technological thinking and action in an effort to improve the application of science to life.

Rational analysis and a rejection of religious or political control have continued to be science's answer to this indictment. In Galileo's time, natural science was the subversive crusade against ignorance and error tenaciously fostered by a theocratic establishment. Thereafter, the dispassionate search for truth through science became a counter-revolution that has successfully shaken foundations of traditional belief. Understandably, the precious freedom of scientific inquiry fos-

3. The impulse to "return to nature" disregards man's uniqueness as *homo faber*. Under the stress of the law of the jungle—natural selection—man might have continued his biological evolution to form a new species; or as has been the fate of many of our ancestors, to have died out completely in competition with other creations. It is precisely the development of technical culture, the Promethean arts, that has taken man out of the biological competition with other species, and substitutes social institutions in place of biology in the dynamic of historic change.

This is not the place to follow the literary vagaries of the Promethean myth, whose ambiguities offer each generation the same opportunity for reinterpretation as the United States Constitution. Enough to remark that M. Shelley's FRANKENSTEIN (1816) was already subtitled A MODERN PROMETHEUS. *See* E. HAVELOCK, PROMETHEUS (THE CRUCIFIXION OF INTELLECTUAL MAN) (1968); R. TROUSSON, LE THÈME DE PROMETHÉE DANS LA LITTÉRATURE EUROPÉENE (1964); L. WELCH, THE PROMETHEUS MYTH: A STUDY OF ITS LITERARY VICISSITUDES (1959) (unpublished thesis available from University Microfilms, Ann Arbor, Mich., Mic 59-4405); R. WERBLOWSKY, LUCIFER AND PROMETHEUS—A STUDY OF MILTON'S SATAN (1952); Capek, *The Punishment of Prometheus*, in K. CAPEK, APOCRYPHAL STORIES (1949); Kafka, *Prometheus*, in THE GREAT WALL OF CHINA (1946).

4. See Appendix for a more detailed resume of the indictments against technology—an outline of a systematic technopathy.

tered a zeal which often promoted scientism[5] as utopian politics and quasi-religious doctrine. These excesses have flawed the method of science, while a new establishment has co-opted the fruits of the defect.

It may be that the rooting of our contemporary culture in science provides an insufficient argument alone for sustaining the preeminence of rational analysis. Cultures, many of them with very appealing elements, have endured on other foundations—though few have survived the encounter with technology. Many social historians believe that an interest in scientific explanation of natural phenomena is as much a consequence as a cause of a cultural commitment to technology. Yet, whatever one's view may be on the absolute value of science, it is clear that the rational use of technology absolutely depends on a framework of critical scientific inquiry. Otherwise, we are left to allocate scarce resources or even judge the culpability of personal and corporate actions by astrology or hallucinatory inspiration. Much as we aspire to improve upon our present methods of technological assessment, it will not be by this path. A humanity whose numbers approach four billions, and which has glimpsed the benefits, however disputed, of economic development, simply will not eschew technology. It could not do so except by paying an unacceptable tribute to a system of natural law which can offer no guarantees for the survival of men in competition with other species.

Where are we left, then, in the shadow between control and the freedom of unchanneled scientific inquiry? Many will agree that no hell would be worse than large scale technological development without disinterested scientific and moral criticism. On the other hand, many scientists urge that much of the technological imperfection which we now endure results from a neglect of readily available sophistication in the application of science. The discussion is mocked by the truism that our "victories" against hunger, disease and grinding toil pale before our failure to order our human relationships.

The scientist must confront the accumulation of what has been said and written on these subjects. However, in contrast to his use of scientific literature, he finds it difficult to know how to harvest a cu-

5. Aldous Huxley's BRAVE NEW WORLD (1932) was perhaps not the final epitaph for utopian scientism, but it surely began the final chapter in an era of naive technocratic optimism. On the religious front, scientists have been sharply divided about the possibility that the method or substance of science could be used to justify or to revise ethical thinking. *See* W. THORPE, SCIENCE, MAN AND MORALS (1966); H. MARGENAU, ETHICS AND SCIENCE (1964); Raphael, *Darwinism and Ethics*, in S. BARNETT, A CENTURY OF DARWIN 334-59 (1958).

mulative benefit from the commentary. That is to say, prior discussion has lacked the structure needed for *progressive* refinement of our ideas—which process may well include the virtue of allowing many productions to be confidently forgotten.[6]

I. THE PROFESSION OF SCIENCE: DEMANDS FOR CONTROL AND SOME SUGGESTED PERSPECTIVES

The profession of science is the search for truths about the natural world; more precisely, it seeks verifiable generalizations that simplify human comprehension and prediction of natural phenomena. Still more must be said: the truths must be novel and significant—which is to suggest that they are measured according to their impact on the minds of other scientists, a statement which labels science firmly as a human and social enterprise.[7] Both the verification and the significance of a purported discovery often hinge on the exhibition of some kind of *control* of a natural phenomenon. This connects science, almost inextricably, with technology—which might be defined as the instrumental use of scientific knowledge. Science is generally thought of as progressive and cumulative, certainly in comparison with many other professions. It should be noted that science does not encompass all the roles played by scientists—who may also be consultants, entrepreneurs, publicists, or even grand viziers or self-arrogated public personages who exploit their real or reputed expertise of science for many private and public purposes. Decisions regarding control should award scientists in these roles no immunities in the name of the enlargement of knowledge.[8]

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6. In contrast, whether defensible or not, questions in law generally reach conclusive decisions. Even so, the corpus of legal doctrine has a way to grow. Can the same be said, as yet, about the present ethical-political questions? If not, no man can be a useful teacher.

7. *See* A. COURNAND & H. ZUCKERMAN, THE CODE OF SCIENCE—ANALYSIS AND REFLECTION ON ITS FUTURE (1970); J. ZIMAN, PUBLIC KNOWLEDGE—THE SOCIAL DIMENSION OF SCIENCE (1968).

8. Nor should scientific ethics or the law give the scientist any special privileges for invading the privacy or personal safety of human subjects. On the contrary, the scientist is generally and appropriately the object of prior suspicion in such experiments. For example, the common law so vehemently assumes that the layman would not understand the technicalities of an experiment that the rule was created that a subject's "informed consent" would not be likely to survive a retrospectively proven hazard of a level which the law would condone in the employment contracts of police and firemen and which is imposed by the selective service system. No one can argue against the legitimacy of legal control of science in this arena; if ethical experimentation is bound to set higher standards than other human relationships, so much the better! It is typical of scientific work that ethical, as well as technical, problems may be set out with sharper precision and demand a more consistent set of answers than in fields which are more distant from logical rigor.

Certainly, no reader would seriously advocate a control of science which carried with it the calculated diminution of knowledge—nor could this be pursued without the most repugnant correlates of control of thought and speech. However, questions must be asked about the intensity of social support and encouragement for science, the connection of science with technology, and the existing systems of investment in and control of large scale technological applications.[9]

The critical objectivity demanded by the relentless discipline of science falls into unremitting conflict with the personal and guild interests of its practitioners and with many pressures from the world outside the laboratory. Every research grant revives the bureaucrat's dilemma for the scientist—can he retain his professional integrity and ethical sensitivity within a system that he barely influences, and with many of whose effects he inevitably disagrees, but from whence he derives sustenance for himself and his good works? In the case of basic research on university campuses the choice is not so dramatic, despite imputations about funding from the Department of Defense.[10] It is so difficult to program basic discovery that many special purpose categorical programs end up providing diffuse support for projects in biology, psychology, chemistry and physics.[11] Applied work is on a much tighter string, however, and neither the universities nor the individual researchers have the fiscal independence to implement their own sense of priority about projects directly related to military technology on the one hand, and urban, environmental, and health care problems, on the other.

Several approaches might be attempted to restore a more pluralistic market for decisions about the direction of academic and scientific research and to lessen the informal control which must inevitably accompany our system of encouraging and supporting such research.

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9. The demand for technology assessment cannot be separated from the reevaluation of all large scale social actions. Today, for example, the mythology of the gross national product is under long overdue attack—before tomorrow the questioning will encompass free education, public assistance, free speech, the concept of punishment for crime, or private property, all of which have their own incompletely assessed side effects. No institution is inherently immune to questioning; until we reach utopian consensus on basic values, a structure that facilitates questions will continue to harbor conflict. But it is a social rather than a scientific system which must decide what level of conflict is the best compromise between stagnation and chaos.

10. The Defense Department's history of agency-academic relationships includes nothing to compare with the black-listing of prospective consultants for the Department of Health, Education and Welfare.

11. For example, the mustard gas molecule has been used (a) as a poison gas in World War I, (b) to treat cancer, or (c) for research in molecular genetics.

An important and, in the view of many scientists, productive avenue of controlling technology would be to liberate the universities from the external, programmatic restraints of government funding.[12] But this must be only a first step. It is not enough to reallocate funds to a better spectrum of social utilities and research missions. An essential freedom which must be assured is the open exposure of new knowledge—academic faculties were helpless against countervailing demands for secrecy in some government-funded work until they reacted as a community against the acceptance of contracts with clauses that limited free publication of research conclusions. The greater part of "technology assessment" should be done by no single agency with explicit responsibility but by a whole community of critical experts. The most creative act of assessment is learning the right *questions* to ask. The genetic hazards of radiation would never have been thought of had it not been for Muller's esoteric studies with fruitflies. How could we have "assessed" the environmental hazards of an SST without a base of knowledge about the chemistry of the atmosphere.[13] We are deeply aroused today about environmental pollution—perhaps aroused to a fault in response to some apocalyptic absurdities. It is certain, however, that we have yet to discover hazards and opportunities more important than the ones that already exercise us. For many of these challenges, a single creative intellect might hold the key to recognizing a question. No small group of experts—unless it remains in intimate contact with a flourishing, well-informed and effectively critical scientific community—can be trusted with conclusive judgments in the assessment of the most critical challenges of new technologies.

This new exposure of knowledge should be carried over into one of the other important roles which scientists frequently hold—that of consultants to give technical interpretation and advice. The talents of scientist *qua* scientist and consultant may not coincide—most scientific problems are far more sharply defined and encompass more manageable variables than do issues of social policy. Insoluble problems may be attacked at all only after they have been oversimplified to make them accessible to technical analysis. When the domain of the scientific consultant both exceeds his expertise and is kept in con-

12. "Liberate" is a dangerous epithet—the solution of cutting off government support of science altogether is a bit like liberating a man's soul from the devil by the Inquisitorial auto-da-fé.

13. This concern is not confined to the synthetic products of industry—the effect of a corn-diet to induce pellagra, or the hazards of hepatitis from blood transfusions, would be beyond our perceptions if not for a similar web of seemingly irrelevant basic scientific knowledge.

fidence and inaccessible to his colleagues' criticism, the scientist is no longer doing "science," and he deserves the same skepticism as any other politician. He should also be placed under the same burden of ventilating his personal conflicts of interest. Forcing the consultant to publicly render his advice and to publicly defend his conclusions should have a beneficial effect on much of the current public distrust of technology assessment which results from the official secrecy of the executive branch—which retains most of the advisory skills that pertain to federally supported technology.[14] At the very least, Congress must assert the right to technical information of the same quality enjoyed by the executive branch. No less than this is indispensable for legislative responsibility in democratic government.

It is too simple to think that this goal will be achieved only by establishing a Board of Scientific Advisers to Congress. Advisors cannot function *in vacuo*. They must have information to which they react, and this information may be inevitably confidential. There is the danger that if advisors are forced to widely disseminate the input which shaped their decisions such that the President feels that he cannot enjoy the confidence of his official advisors, he will revert to less well informed but politically reliable cronies. However, most issues do not have such a high order of political sensitivity. Congress retains the means to nudge the executive toward a higher level of voluntary cooperation. Congressional committees should be able to identify the principal advisors to the executive on particular projects, and, with minor changes in law or custom, to invite them to ventilate their recommendations. The example set by Dr. Richard Garwin,[15] testifying against the SST even while the formal report of the advisory committee he chaired remained sealed, may encourage Congress to expect to be well informed by the relevant experts—and to balk when the executive unreasonably rests on his constitutional privileges. Beyond these steps, blocs of Congressmen who share a common ideological or practical-political outlook can recruit their own consultants, often from their own constituents and political supporters. The will would soon create the means.

14. The "Pentagon Papers" incident has already evoked a healthy public reaction to the abuses of executive secrecy. It should accelerate reforms that might avert such personal and public tragedies as the civil disobedience of Daniel Ellsberg.

15. *See* Wenk, *SST—Implications of a Political Decision*, 9 ASTRONAUTICS & AERONAUTICS 40-49 (1971). Dr. Garwin's testimony appears in "Economic Analysis and the Efficiency of Government: Part 4—Supersonic Transport Development," *Hearings before the Subcomm. on Economy in Government of the Joint Economic Comm.*, 91st Cong., 2d Sess. pt. 4, at 904 (1970). The report dated March 30, 1969, was released August 19, 1971, and appears in 117 CONG. REC. H8553 (daily ed., Sept. 16, 1971).

II. POPULAR PRESSURE AND THE CONTROL OF TECHNOLOGY

A great current fallacy is the confusion of science with technology. Nothing was more irritating to the basic scientists a few years ago, pleading for better funding for the National Science Foundation, than to be told, "What do you want? We've already invested billions in putting men into space and landing them on the moon!"

It is easy to point to innumerable instances of how huge technology has become intolerable for lack of *enough* scientific sophistication. For example, heavy industry is built largely on the science of the turn of the century. Until very recently, however, nothing which was tried, including economic incentive or governmental regulation, moved the automobile industry to serious scientific investment related to problems of air pollution and traffic safety. The most grievous environmental problems have fairly straightforward technical solutions; too often lacking is a motivational system that will encourage the implementation of such solutions. Indeed, it may be futile to talk of the regulation of *technology* before we understand some important conflicts of interest among people and groups.

Technology and the law are frequent antagonists. Technology, as a profession and as a respect for innovation, carries enormous institutional responsibility. Our social framework of rights and privileges has evolved pragmatically, slowly and painfully within a particular context of technical possibility. But technical advances bring about new powers for exploitation, which will be lucrative and abrasive where they invade new territory in advance of custom or customary law. Technology will be the visible culprit, precisely because law has not anticipated and deterred the abuses.

Technology and the industrial capitalism of the modern state often have a similar relationship. The control of technology opens the door to issues that pervade our entire culture.[16] This is nowhere more clear than in the isolated, and hence more manageable, facet of the control of technology assessment—strictures on the procedures for the evaluation of a specific innovation. In a free enterprise system, technology assessment can be explicitly mandated in government projects, which are usually justified under the coloration of "the general welfare." However, in our economic system, government regulation or licensing, procurement, subsidy, and taxation permeate the private sector and, thus, the considerations which enter into the assess-

16. *See* Appendix.

ment of governmental technology must, in the long run, apply to all technological projects. But this inclusion creates philosophical problems and political conflicts—since the asserted need for technology assessment comes directly into conflict with the hypothetical control of assessment in the private sector by the market mechanism.[17]

Further, the most important governmental decisions relating to technology will concern fundamental *political* commitments about the nature and purposes of government. Questions like the permissible extent of military technology can never be answered by "technology assessment" as it is usually interpreted.[18] Granting that the cost-benefit analysis of weapons systems sets an admirable example to other technologies in the exposure of the premises and specific arguments for priority choices, conflicts of political judgment rather than technological confusion dominate controversies over defense policy today. The recent ABM debates are illustrative. There, the underlying issue was not so much the technical feasibility of the ABM system (which neither Congress nor most of the contestants could reliably judge) but rather expectations about the shaping of Soviet defense policy in reaction to our own. Thus, whether building an ABM is a cost-effective "bargaining chip" is a question unlikely to be answered by any process of technology assessment.

17. This control will be subject here only to a few observations. One salient externality which, of course, distorts the market mechanism is the cost of bargaining—the effort which the consumer will have to make to obtain the information to conclude an economically efficient transaction. Another is the social role of the corporation, which is scarcely confined to profits when it is the principal patron of the political establishment.

The expositions of R. ARON, PROGRESS AND DISILLUSION—THE DIALECTICS OF MODERN SOCIETY (1968), J. GALBRAITH, THE NEW INDUSTRIAL STATE (1967), and others have articulated the evolution of industrial capitalism in modern technological societies. In the West and the USSR alike, capital is the limiting factor in economic life, so that capital both engenders and is generated by industrial productivity—hence the central role of the gross national product (product efficiency) as the index of national success. Government can, in principle, divert capital from reinvestment to other national or welfare needs. In practice, only national defense has made an urgent enough appeal; but as capital becomes more abundant, the surplus will be irresistibly sought for more welfare-oriented applications. This has ramifications for technology assessment. Besides being condemned by environmentalists, the SST plan was attacked by many businessmen on ideological grounds —that the government should not intervene in the large scale allocation of capital in civil technology. However, the Lockheed precedent is bound to open the door to many more persuasive initiatives for civil technologies which would not be capitalized in a totally free market economy.

18. For almost 30 years, military needs have dominated technological (as distinguished from scientific) investment in the United States. This preponderance is a conscious, well-ventilated political decision. I believe it to have been misguided in scale, a characteristic which no doubt blinded particular decisions of past policy to the predictable reactions of other actors. But the military emphasis can be traced to an error shared by a palpable

Finally, the assessment of technology has finite limitations which we are only now beginning to understand. First, such assessment will be frustrated if attempted on the basis of individual projects, since many technopathies stem from the cumulative impact of innumerable technological advances. On a larger scale, I readily adhere to the plea for an "attitude toward science and technology . . . which recognized both their potential usefulness and their potential harmful consequences, and sought ways to enhance the former while reducing the latter."[19] In judging long range consequences, we must preserve some humility. A comprehensive theory of history is as illusory as the ideal of Laplace's determinism in physics—which was grounded in the proposition that we could predict the future history of the universe if we but had a complete description of its present state. We simply cannot possibly foresee all the consequences of adopting a particular innovation, or not adopting it, for that matter.[20]

But the realization that the system which advances technology is filled with internal conflicts and that there is limited utility in assessing technology on a case-by-case basis does not remedy the undeniable need for some control over technological growth. Nor does it answer the demands of those who cry that science should be controlled because it serves as the foundation for technology. It can be said that such clamor for technology control is as grave a reflection on the sluggishness of our institutions as it is on the "hazards" of science. How shall we set about to try and repair a political system that took decades

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majority of the electorate. Scientists, even "technocrats," have been among the most articulate critics of needless overkill. One can question how much of the demand for controlling "technology" is simply an evasion of a direct confrontation at the polls with the political challenge of levels and forms of defense expenditure.

Likewise in urban transport, education, and other civil policy areas the assessment of technological expenditure can hardly be separated from fundamental political decisions about the allocation of social efforts. No one, as far as I am aware, will defend a technological imperative apart from the purposes such a technological innovation will serve.

19. E. CHASZAR, SCIENCE AND TECHNOLOGY IN THE THEORIES OF SOCIAL AND POLITICAL ALIENATION (1969).

20. "A Study of Technology Assessment" (H.R. Comm. on Science and Astronautics, 1969), prepared by the National Academy of Engineering, concluded that it could not systematically analyze the ramifications of a particular technological introduction. It confined itself to problem-initiated studies, like the choice of alternative strategies for the use of television and of computers. The report wisely reflects that in "the selecting of problems to be addressed, important social and political impacts could be overlooked." I would not discourage effects of problem-oriented assessment, but let no one believe that this will answer the fundamental criticisms that have provoked these studies. A similar study, "Technology: Process of Assessment and Choice," by the National Academy of Science in July, 1969, took a broader philosophical approach, more nearly consonant with the present article.

to respond to air pollution? It has been decades, after all, since Haagen-Smit discovered that automobiles, rather than industry or backyard incinerators, were the principal sources of photochemical smog.[21] Shall we abandon hope for the institutional rectification of such abuses, and strike out at the creative sources of scientific and technological innovation in the belief that these breed monsters beyond hope of human control? If we do, to which era of historical development would we revert? Or do we have other alternatives?

Certainly, we have seen an extraordinary evolution in the sensitivity of the electorate and of government to problems of environmental depredation. The rejection of the SST and the recent promulgation by the Atomic Energy Commission of 100-fold more restrictive standards of radiation release from nuclear power plants are both recent examples which demonstrate that we are finally learning how to grope toward sensible policies. We may have reached a symbolic turning point in our sense of command over technological development. Techniques of regulatory control can be devised once a reasonable consensus is reached by a politically effective coalition. The growth of vigilant, technically well-informed environmentalist and consumer groups has been one of the vital instruments of this political reorientation. To be sure, many problems remain in disagreeable and dangerous confusion. Some, like the certification of DDT and other pesticides, are mainly an historical legacy from a more primitive era. Action now, in the form of existing and pending legislation, will make it unlikely that new pesticides will be able to reach the market so carelessly. However, it will be far easier to control these and other new technological problems by the enlightened refusal to allow premature use, than it will be to solve our older technological problems—in which powerful manufacturers and users have long vested interests and to whose benefits we are all too well accustomed.

III. SCIENCE, TECHNOLOGY AND THE LAW

No discussion of the advisability and the effect of assessment of science and technology would be complete without some reference to changes in other areas which must accompany such reorganization. As the relationship between scientist and society changes, so also must the system which organizes these rights and responsibilities change. For traditional law has developed a fashion of controlling only the power

21. Haagen-Smit, *Chemistry and Physiology of Los Angeles Smog*, 44 IND. ENG. CHEM. 1342 (1952).

actually in our hands. We distinguish between physical acts on the one hand, and speech or thoughts on the other, precisely because our intentions cannot kill. If they did, or if we discover that "free speech" in new technological dimensions (like violence in children's television programs, or mass advertising generally) has harmful, but closely related, side effects, we may have to rethink well-trodden ground. We may well discover that we must resolve ancient conflicts of rights along new lines. Such redefinition may be burdensome and difficult, if not impossible, but it is the unavoidable price of any progress.

The areas of conflict which must be considered might be taken from the different ways in which technological progress currently alters our physical or cultural environment. For example, public education to higher and higher levels becomes ever more a personal right as well as a social utility, in proportion to the demands of the culture that education serve as a prior condition for achieving the constitutional rights of life and liberty. Our social response to this principle still suffers from serious biases toward the education of youth—an approach which is in total disarray in accommodating older workers to the exigencies of technical advance. This used to be a problem mainly for the semi-skilled. Now, some overspecialized professionals, like engineers, are feeling it as badly. We cannot possibly take full advantage of the potentials of new technologies unless we put first emphasis on keeping people off of the scrap heap. However, we should be able to devise a response more creative than the frustration of work-saving technologies by some unions. But no acceptable solution may be forthcoming until the basic right to share in technological progress and the corresponding obligation to keep one's brain alive are more generally accepted.

Privacy is another sphere where new law must regulate new technological opportunities. Of course, the bureaucratic innovation of dossiers on individuals preceded the development of computer technology. The computers have given government some additional headway against private citizens, but the main threat to privacy comes from the spin-off effect which has made data-banks inexpensive and, therefore, commercially available. The cheap provision of credit information has, in turn, hastened the evolution of a cash-less economy—a general convenience but a particular disadvantage to citizens whose credit ratings are impaired. It will cost a great deal to keep the records perfect, that is, to give every citizen some due process against the unfair, inadvertent, or malevolent impairment of his record. Even so, the public has implicitly accepted these costs in order to achieve better justice, as expressed in the Fair Credit Reporting Act of 1970.[22] However, government records present an unresolved problem. Senator Sam J. Erwin, Jr., for example, deplores the relentlessness of computers[23]—which have no mercy and never forget. But to leave forgiveness to the lapse of human memory would be to expose us to capricious, vengeful, or extortional exhumations by the private or public investigator. There is no objective evidence that computers have made worse bloodhounds than was Senator Joseph McCarthy. The basic, and generally unidentified, issue is whether a man has the privilege of the non-remembrance of things past.

The area of environmental concern offers the paradigm problem of the adjustment of rights. I need hardly elaborate on the central issue of the unjust private conversion of common "property rights" in pure air and water, safe foods, consumer products in general, rights-of-way, quiet, esthetic landscapes, access to sunlight, and so forth. It is difficult to change the rules of the game in mid-course without doing an injustice to someone—our course is doubly difficult because we are only sometimes certain of the aggregate social benefit. Should some Navajo be deprived of the opportunity of exploiting his landscape by a forced tradeoff for the possible benefit of gainful employment in the Four Corners' power plant? Do I have an inherent right to the unaltered enjoyment of natural rainfall on my acre, even at the cost of depriving some metropolis of protection against hurricanes via cloud-seeding?

Traditional law has failed to harmonize conflicting interests generated by environmental hazards because of the legal fiction of causal responsibility, a theory totally at odds with modern statistics. As the law currently stands, my estate would have no tort claim against a polluter (assuming, the existence of all other necessary elements) unless I (that is, my representative) could show a direct causal link between my death from emphysema and his contribution to the mass of air pollutants. I might establish that air pollution generally tripled the risks, and that a particular industry was responsible for five percent of the pollution—but I would still have no case for a statistical assessment of fractional damages. Since most environmental pollution is

22. 15 U.S.C. § 1681. The evolution of this law is an exemplar of the readjustment of rights and costs in response to new technology. However, the incremental cost to the credit-furnishing system—a technological assessment of the new law itself—was never clearly exposed.

23. 118 CONG. REC. H5576 (daily ed., June 21, 1971).

characterized by this mathematical anonymity, the recourse of injured parties against collective tortfeasors is gravely hindered. Similarly, the "public nuisance" concept has manifestly failed in the face of pressures from the economic beneficiaries of the tortious conduct in question. Even when more people profit from a technology than suffer from its side effects, as long as a few remain uncompensably exploited the legal system can be challenged as neither just nor economically efficient.[24]

As a result of current inability to deal with these technologically spawned problems, we may well see the invigoration of a new institutional form with the capacity to help us reach some solutions—the registered, non-profit advocate of consumer and environmental interests, already exemplified by the public interest law firms. If such advocates could retain fees commensurate with their overall commitment to such litigation, from damage recoveries in successful class action suits, they would have the means to monitor and potentially to deter a wide range of potential abuses. With the help of skilled technical support, they would further new approaches to technology assessment. Allied with other consumer organizations, these pluralistic institutions could compensate for the peculiarly privileged status which corporate management and labor unions have come to occupy in our political system. The eventual social impact of this third force could be magnified through consumer education and research. If such institutions developed access to as much political pressure as is wielded by big business and labor, we might enjoy a new harmony in the powers of different role-structures in the social order.

IV. EXPERTISE

Although valuable as a tool for solving the technological problems, expertise has distortions, many of which have already been alluded to.[25] Besides the inherent problems of conflicts of interest and differing levels of competence, experts may also malfunction when they are asked, and fail to reject, the wrong *questions*. For example, a long

24. The converse confrontation is already familiar in class actions, where many claimants must join to make a suit profitable, for the collective injury is divided into very small units. Even so, justice is hindered by the same problems of allocation of probabilistic responsibility, as well as by other obstacles to class actions in many jurisdictions. The rapid development of the class action suit has been momentarily thwarted by Congress' refusal to liberalize such litigation in the federal courts. One of the principal arguments against the bill, the Consumer Protection Act of 1970, was a fear of harassing suits intended for extortion rather than the litigation of a fair cause. *See Hearings on S.3201 Before the Sen. Comm. of the Judiciary*, 91st Cong., 2d Sess., at 362 (1970).

25. See text accompanying note 8.

series of expert panels have reviewed the criteria for population exposure to environmental radiation from weapon-testing, medicine, and diverse peacetime nuclear power usages. The able, conscientious men on these panels (sometimes including the present author) had no difficulty in finding the common boundary of their knowledge of the hazards of a given dose of radiation. They could make rough estimates of the expected number of deaths and other miseries—but this was all they were competent to do. They should have refused to arrogate the wisdom—which they failed to do—to balance these costs against the anticipated benefits. Instead, the benefits were rarely analyzed, and when dealt with, were stated imprecisely.

Indeed, what was demanded of such committees was a policy judgment, cloaked in technical detail. As a result, many of the fundamental issues remained obscure in the public mind—even though they had been ostensibly fully discussed. It is to this perhaps more than any other single factor that the hysterical backlash against nuclear power can be attributed.

The kind of statement I would now advocate would be in the following form. It is paraphrased from my own writings on the social cost of radiation[26] but I do not here defend the numerical values.

> If we assume we are willing to make a social investment of \$250,000 to preserve one human life during the next 30 years, the social cost of one man-rad[27] of radiation is about \$100. At this exchange rate we are making a better bargain than most of our health-saving transactions; but we cannot argue whether it is a good bargain in absolute terms. Nor does an argument about aggregate cost allow for the redistribution of costs and benefits, to those who gain, from those who may suffer. It also ignores the possible costs of alternatives to nuclear power such as more expensive but less polluting ways of burning fossil fuels, or of restrictions in the growth of electric power. These costs have not been very deeply studied.
>
> Until recently, the promulgated standards of population exposure to radiation were set at a theoretical limit of 0.17 rad, *i.e.*,

26. *See* Lederberg, *Squaring an Infinite Circle—Radiobiology and the Value of Life*, 27 BULL. ATOM. SC. 43 (Sept. 1971).

27. "Man-rads" express the total population-exposure to radiation, the aggregate of individual exposures. In rads this is, of course, the same as the product of average exposure per capita multiplied by the number of people involved. Merely to question the economic or social cost of radiation per man-rad has advanced the clarity of argument in this field. It cannot, of course, repair the 10- or even 100-fold uncertainty in the reliability of our estimates.

> the equivalent of $17 per person per year. This is comparable to what we already experience from natural sources (0.1 rad) and medical X-rays (0.05-0.1 rad). More recently the AEC has calculated, and now sets as a regulatory limit, an upper limit of exposure by virtue of nuclear power operations which is only a few percent of this figure, so that the average social cost should not exceed a few cents.
>
> The odds of catastrophic failures or other deviations from the regulatory standards are not included in these calculations, and demand the expertise of the engineer rather than the biologist.

In my view, the expert advisor has no more vital responsibility than to clarify technical issues so that the essential policy questions become accessible to the judgment of the community at large. He may sacrifice this for higher goods in order to advise the government on legitimately[28] classified issues of great urgency.

If national security makes transcendent claims on scientific expertise, it should remind us that the humanly-rational assessment of technology is futile so long as most of it is hostage to an armed world conflict. Paradoxically, while national security rests squarely on technological preeminence, the most nearly universal of contemporary ideologies, aspirations, and works is found in the pursuit of pure science.

APPENDIX

A Panoply of Concerns About the Impact of Science and Technology on Various Systems

The following classification does not pretend to be precise; every category interacts with every other one. Nor does it explore the network of actions and reactions—that would be the cultural history of western society.

A few *cultural reactions* are indicated by italics.

As stressed by Monod,[29] the "authentic discourse" common to modern science insists that value-principles be exposed as explicit axioms, rather than asserted to be imminently or logically demonstrable. This table implicitly rests on a liberal-humanistic outlook. Others are free to assert conflicting value-axioms.

28. "Legitimately" opens another controversy, unlikely to be resolvable by any scientific argument.

29. J. MONOD, CHANCE AND NECESSITY (1971).

System	Man in relation to:	Impact and *cultural reactions* to impact
Ethical (Religious)	God(s); perception of his own nature	Refutation of superstitious belief (Galileo; Darwin; Freud); *censorship* Discredit authoritarian doctrine; skepticism *inquisition* Preponderance of the objective; short shrift to non-scientific forms of creativity and wisdom *anti-intellectualism* Anomie; religious crisis; moral libertarianism *counter-culture* *Can man assume God-like responsibility for his own purposes? Whence values?*
Biological	his body, pain & death	Public health, especially disappearance of infant mortality Population explosion and other demographic shifts; *ambivalence of benevolence;* unequal access to health facilities Moral dilemmas of resource allocation for preservation and prolongation of individual life Ethics of human experimentation; of sanctions on drug abuse; of abortion; of saving damaged fetuses Scientific deflation of racism Possibilities of autocratic manipulation of behavior or of genotype with new biological tools Evolutionary consciousness and dilemmas of genetic intervention (*see* Ethical)
Environmental (primary economic development) Ecology	nature: land	Mechanization of agriculture Potential alleviation of famine; population explosion Urbanization and alienation from land (*cf.* child labor) Wastage of wildlife, natural beauty Exploitation of commons (the multitude and the future) Environmental pollution and disease; *natural health movements*

System	Man in relation to:	Impact and *cultural reactions* to impact
Industrial (secondary economic development)	work, power	Industrial revolution Potential alleviation of toil (replacement of muscle-power with machines) Technological unemployment; industrial child labor; *Luddites; labor unionism* Rising expectation and imperfect realization of equalitarian opportunity; *communism; welfare politics*
Industrial capitalism (exhibited in US, Europe, USSR) Tertiary (ec. develop.)	systems of production[30]	Unprecedented productivity Efficiency as autonomous (self-nourished) principle in the rational allocation of capital Assembly line; work alienation; mass consumption/advertising/culture; *counter culture* Affluence; *anomie from disappearance of economic imperative (work ethic)*; Leisure; disappearance of child labor and prolongation of economically dependent period beyond puberty *generational reactions* Obsolescence of human skills; erosion of self-value upon displacement by machines Centralism; bureaucracy; market failures, externalities; *Technology Assessment consumer and environmental lobbies* Alienation of consumers from goods (unsafe products; cost of information); *government regulation* Index ethics (I.Q.) and economics (G.N.P.)—simplified models (social scientism) and suboptimal designs

30. *See* ARON, *supra* note 17, GALBRAITH, *supra* note 17, and J. ELLUL, THE TECHNOLOGICAL SOCIETY (1964).

System	Man in relation to:	Impact and *cultural reactions* to impact
Social & political Interstate	state & national culture	Acceleration of social change through redistribution of power; egalitarianism; social mobility and disappearance of hereditary castes and of extended family; *social confusion* (*e.g.* racial separatism vs. integration); *future shock*[31] Vulnerability of complex system to disruption by dissidents (hijacking; strikes) Rationalization of police powers; government power over citizens—including invasion of privacy Corporate wealth and unfair pressures on political process A new priesthood: "the experts"; imputations of an unaccountable intellectual elite; relentless demands on citizens to keep up with evergrowing complexity; *participatory democracy and demands for simplification of political organization*
Interstate	national sovereignities	Ultimate weapons: risks of catastrophe (H bombs; Biological Warfare); *international integration and law* Stable (?) deterrence of global conflict Arms race; arms trade; military-industrial complex and domestic political consequences; *isolationism* Means, therefore temptations for conquest or insurgency

[31] *See* A. Toffler, Future Shock (1970); H. Muller, The Children of Frankenstein (1970); V. Ferkiss, Technological Man (1969); R. Merton, Social Theory and Social Structure (1968); E. Spicer, Human Problems in Technological Change (1965).

Note on Appendix, pp. 612-613

This table should be viewed as a first effort to frame a taxonomy of the problematics of scientific progress.

In further work, it would probably be useful to separate the perspectives of different historical epochs-that is to suggest how this problem would have been viewed at different periods (and by different cultures).

Then, and most appropriately, more attention could be focussed on the special problems of the modern (and post-modern?) era.

One difficulty I have in understanding and answering anti-scientific protest is in elucidating the point of reference of the critic -- that is, just what era of historical development he would wish to return to. A more constructive outlook would be to try to trace preventive remedies for predictable side-effects of new technologies, on the one hand, and incremental ameliorations of the historical legacy on the other.

One of the main points of this discussion is that much anti-"scientific" thought is directed against the alleged misuse of technological instruments within the established system of political power. In frustration at self-perceived helplessness about that system, the critic then mobilizes his attack on the instruments. (In distinction, Ellul, Mumford and some others stress the autonomy of "technique" as a prime mover of political change.)

A rational discussion of complaints about science is then inextricably interwoven with the underlying value systems of the protagonists. In a sense this table also attempts a taxonomy of these value systems, organized according to the social role of the individual, and of his reference groups.

I would be most grateful for critical discussions, or for references to any comparable efforts to map the field and to provide models for systematic analysis.

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Correction to p. 597

The reference to the burning of the great library of Alexandria "shortly after the death of Christ" is a garbled version of an already dubious legend. (Cf. Gibbon, Decline and Fall of the Roman Empire, Chap. 51.) The editor is responsible for this insertion of a piece of anti-Muslim propaganda that doubtless dates back to the early Crusades.